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USE OF MATLAB TO UNDERSTAND BASIC MATHEMATICS

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ABSTRACT

In this paper, we talk about the ways in which computer technology can be used to understand basic mathematics. Matlab is a high-level mathematics package designed for doing numerical computations and graphic. Toolboxes are comprehensive collections of Matlab functions that extend the Matlab environment to solve and visualize particular classes of problems. In particular, starting with the Matlab desktop layout, we will illustrate eight topics in basic mathematics using Matlab: Matlab as a calculator, order of precedence, factoring and expanding polynomials, arrays, vectors and matrices, solution of system of linear equations, solution of simultaneous linear equations, operations on polynomials, solving polynomial equations, build-in Matlab functions and plotting.

Keywords - basic mathematics, computer technology, matlab, numerical analysis, toolbox.

I. INTRODUCTION

The use of computer technology in teaching mathematics has become a famous part of most preparatory mathematics classes like calculus. A recently conducted research project [1, 2] examined the influences on attitudes and learning of students who were using Matlab, and found that almost all students behaved positively to Matlab for easy use of computation and graphing. In addition, the use of the Matlab software as a tool was found to have a strong impact on the learning strategies adopted and on their confidence towards mathematics. On the other hand, [3] found that students with high computer mathematics interaction realise that computers improve mathematics knowledge by providing many examples allow user to focus on major facts by reducing mechanical work, and find computers cooperative in connecting algebraic and geometric ideas. Matlab is a high-level programming language with an interactive surroundings for numerical computation, visualization and programming function. The name Matlab stands for " Matrix Laboratory ". Matlab software was invented by Cleve Barry Moler for his students who were studying at the University of New Mexico so that they can use this computing package easily in numerical analysis without writing Fortran. Since Matlab has dominant symbolic math potential, therefore instead of making calculations on known numbers, we can make calculations on symbolic expressions. Matlab features a family of application-specific solutions called Toolboxes. Toolboxes are complete collections of Matlab functions usually known as M-files that extend the Matlab surroundings to solve some particular classes of problems. Numerous research papers meticulous the learning process of Calculus using Matlab [4] and Microsoft Excel [5] but no one study up the learning of basic mathematics. In this

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paper, we will talk about how to learn basic mathematics using symbolic toolbox of Matlab [6] and here we will use the latest version R2016a of Matlab to illustrate the various aspects.

II. THE MATLAB DESTOP LAYOUT

The Matlab layout is divided into four windows (indicated by ovals in Fig.1) :

1. Current Folder (Left) - It has a toolbar with your current directory shown. All your work will be saved in this directory.
2. Command Window (Centre) - Where you will type in all commands after the double arrow " >> "
3. Workspace (Top right) - Which will show your current variables.
4. Command History (Bottom) - Showing a history of commands in the order you typed them.

At the top of the screen we will see tabs Home, Plots and Apps. When you start Matlab, it shows all modes (menu items) in Home tab grouped by their functions. At the bottom of Home, Plots and Apps tabs, you will see names of the functional groups for a particular tab.

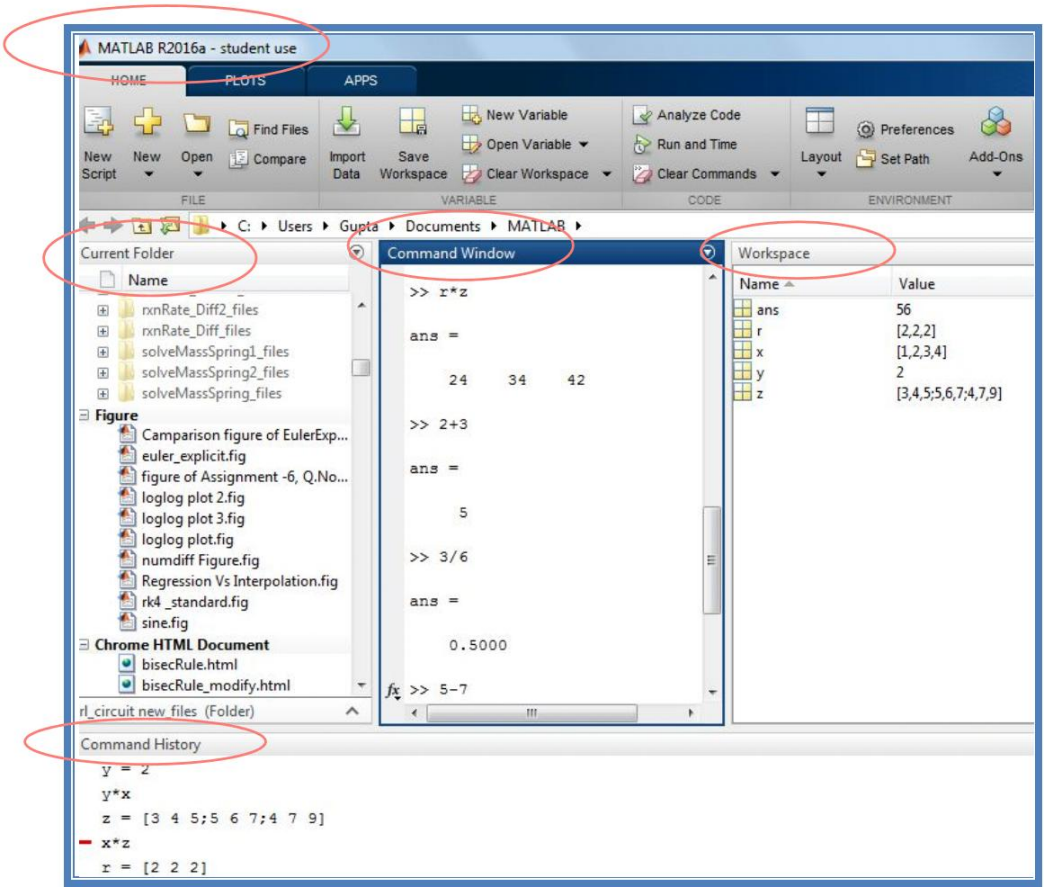

Figure 1: Matlab desktop layout

III. BASIC MATHEMATICS TOPICS AIDED WITH MATLAB

3.1 Matlab as a Calculator

Matlab can be used as a powerful calculator. You can use operators "+" to add, " − " to subtract, " * " to multiply, " / " to divide and " ^ " to exponentiation.Matlab prints the answer and assigns the value to a variable

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called ans. If you want to perform further calculations with the answer, you can use the variable *ans* rather than retype the answer.

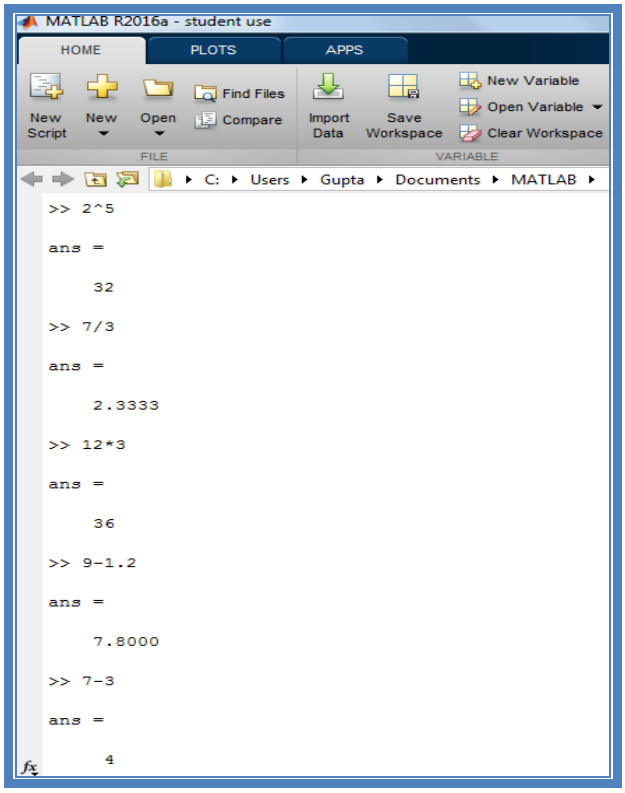

Figure 2 : Matlab as calculator

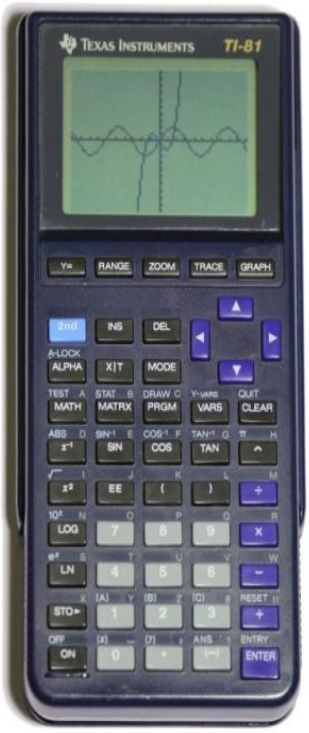

Figure 3 : calculator

3.2 Order of Precedence

It is essential to note the order in which algebraic expressions are calculated. This is called the order of operations or the order of precedence. As you probably expect, multiplication and division are calculated before any addition and subtraction. In general, the arithmetic operators in order of precedence from highest to lowest level are shown in the following Table 1:

Table 1 : order of precedence

Precedence	Operator	Name of operator
1	(.....)	Parentheses
2	^	Exponentiation
3	/	Division
4	*	Multiplication
5	+	Addition
6	-	Subtraction

Expressions can be evaluated from left to right using PEMDAS rule i.e. starting with parentheses, then use power operation (exponentiation) having the highest order of precedence, followed by both multiplication and division having equal precedence, followed by both addition and subtraction having equal precedence. Fig.4 shows the influence of the parentheses location on the expression.

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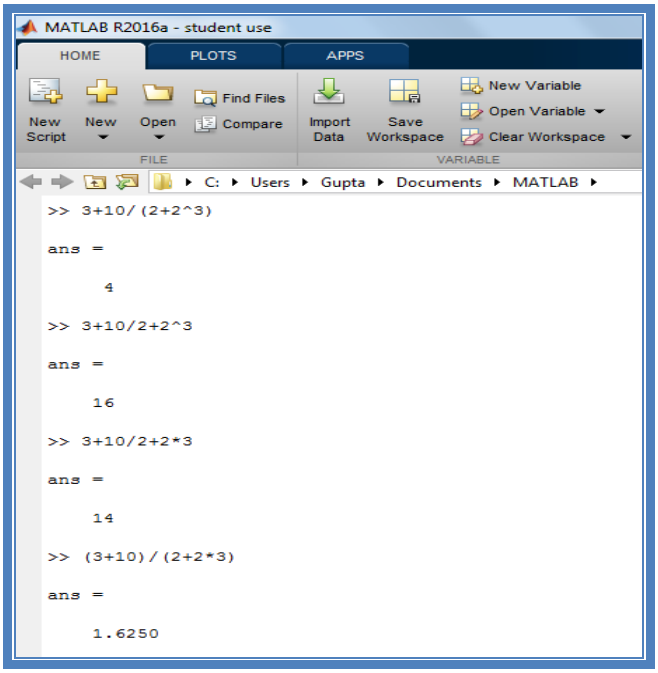

Figure 4 : influence of parentheses on the arithmetic expressions

3.3 Factoring and Expanding Polynomials

Using Matlab's Symbolic Math Toolbox, you can carry out algebraic or symbolic calculations such as factoring polynomials. To perform symbolic computations, you must define the variable in the expression using the command "syms x" to define x variable. Fig.5 shows how to factorize and the polynomial expression in Matlab using the command "factor(expression)".We can use the "expand(expression)" command to verify the result of factoring.

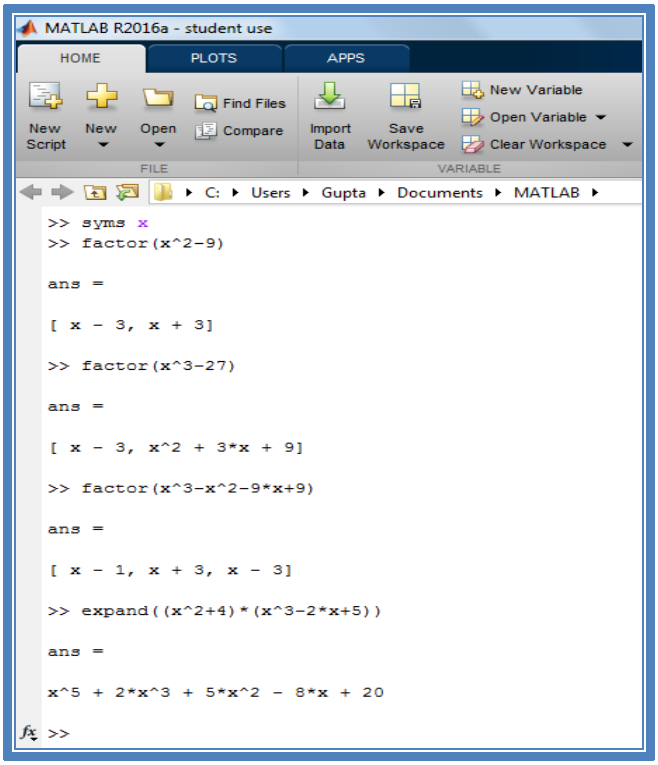

Figure 5 : factoring and expanding polynomials

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3.4 Arrays, Vectors and Matrices

An array is a collection of values that are represented by a single variable name. One-dimensional arrays are called vectors and two-dimensional arrays are called matrices.

3.4.1 Row and Column Vector

An array of dimension $\mathbf{1} \times \boldsymbol{n}$ is called a row vector, whereas an array of dimension $\boldsymbol{m} \times \mathbf{1}$ is called a column vector. The elements of vectors in Matlab are enclosed by square brackets and are separated by spaces or by commas. So, a row vector may be defined as $\boldsymbol{x} = [\mathbf{1\ 2\ 4\ 7}]$ or $\boldsymbol{x} = [\mathbf{1, 2, 4, 7}]$.

Column vectors are created in a similar way, however, semicolon $(;)$ must separate the components of a column vector. On the other hand, a row vector is converted to a column vector using the transpose operator. The transpose operation is denoted by an apostrophe or a single quote $(')$. So, a column vector may be defined as $\boldsymbol{y} = [\mathbf{4; 5; 6}]$ or $\boldsymbol{y} = [\mathbf{4\ 5\ 6}]'$.

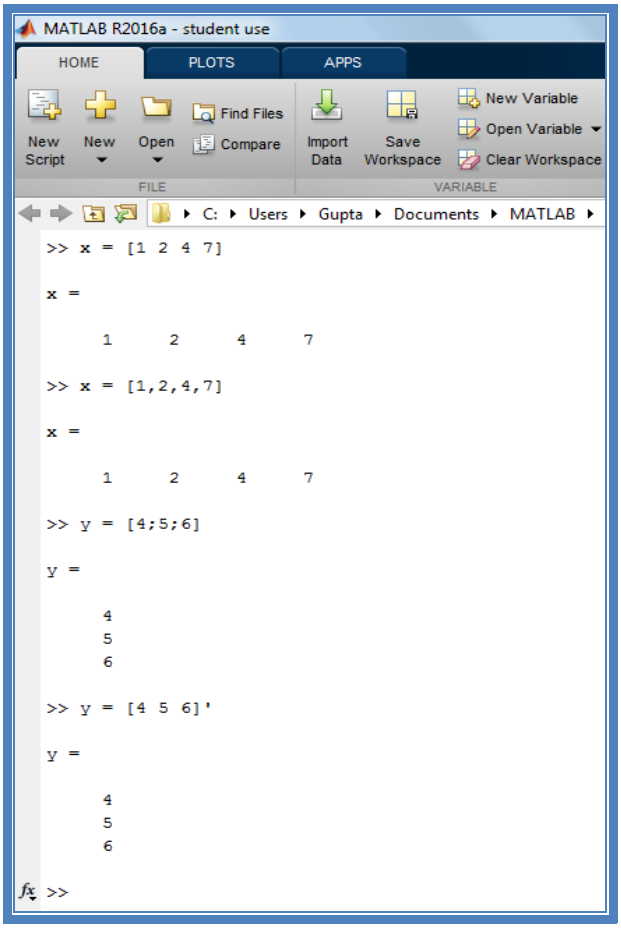

Figure 6 : vector and column vectors

3.4.2 Matrix Arithmetic Operation with Matlab

A matrix is an array of numbers. To type a matrix into MAT LAB, you must

- begin with a square bracket, [

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- separate elements in a row with spaces or commas (,)
- use a semicolon (;) to separate rows
- end the matrix with another square bracket,].

To enter a matrix $A = \begin{pmatrix} 1 & 3 & 5 \\ 6 & 4 & 2 \\ 0 & 6 & 9 \end{pmatrix}$ type, $A = [1\ 3\ 5\ ;6\ 4\ 2;\ 0\ 6\ 9]$ in Matlab.

MATLAB allows arithmetic operations : addition(+), subtraction(−), multiplication(∗) and power(^) to be carried out on matrices. Thus,

- A+B or B+A is valid if A and B are of the same size.
- A*B is valid if number of columns in A is equal to number of rows in B.
- A^2 is valid if A is square and equals A*A.
- α*A or A*α multiplies each element of A by scalar α.

On the other hand, array arithmetic operations are done element-by-element. For this, the period character(.) is used which distinguishes the array operations from the matrix operations. However, since the matrix and array operations are the same for addition (+) and subtraction (−), therefore the operators (.+) and (.−) are not used.

The list of array operators is shown below in Table 2.

Table 2 : array operators

.*	Element by element multiplication
./	Element by element division
.^	Element by element exponentiation

Table 3 : summary of matrix and array operations

Operation	Matrix	Array
Addition	+	+
Subtraction	−	−
Multiplication	*	.*
Division	/	./
Left division	\	.\
Exponentiation	^	.^

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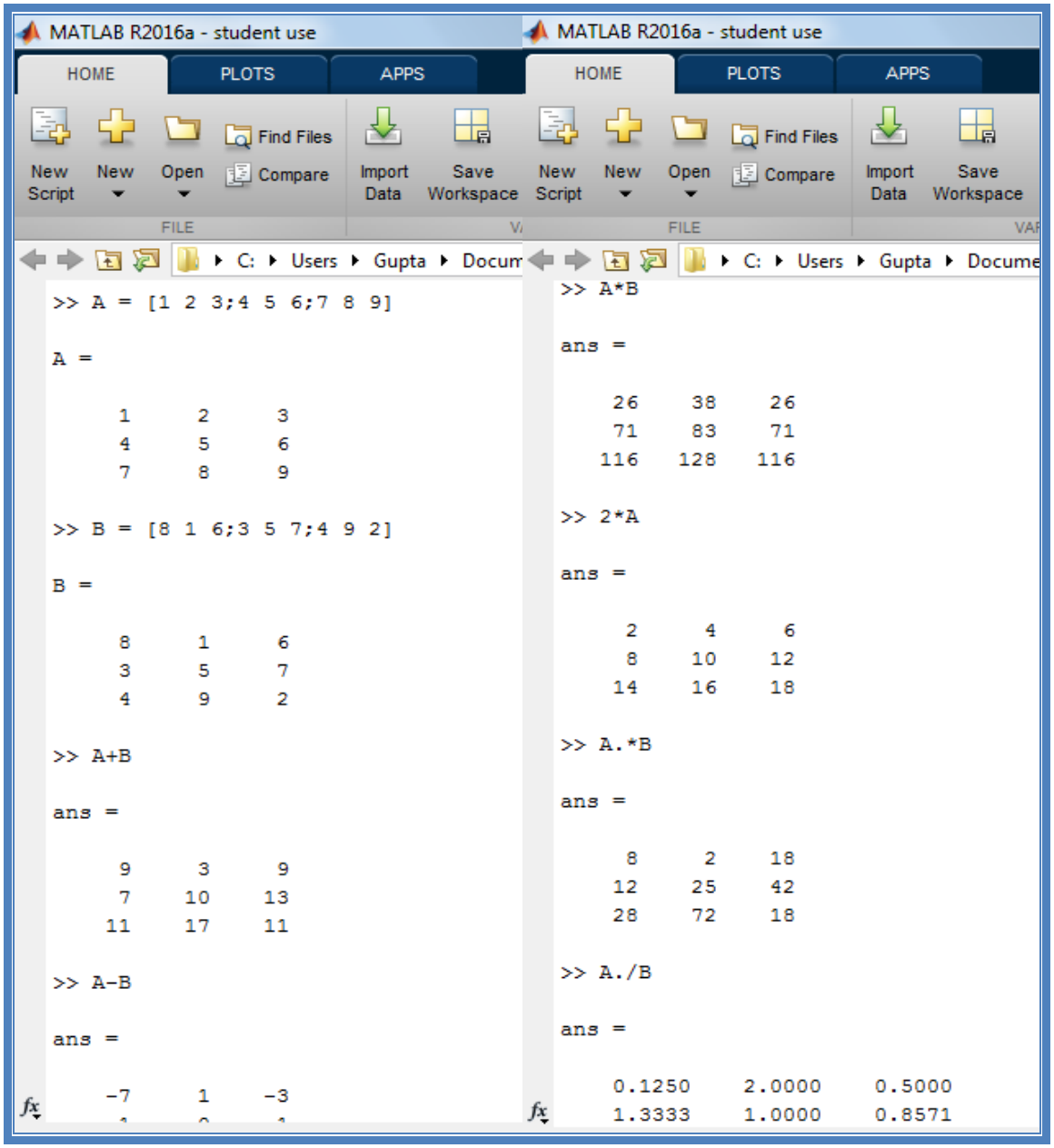

Figure 7: matrix operations with Matlab

3.5 Solution of Simultaneous Linear Equations

Solving a system of simultaneous linear equations is easy in Matlab. Solving a set of equations on a computer is nowadays as basic as doing arithmetic additions using a calculator. Let's see how easy Matlab makes this task. Consider the following set of equations

$$-6x - 2y + 2z = 15$$

$$-3x + 4y - 3z = 13$$

$$2x + 4y - 7z = -9$$

In the matrix form the system of linear equations can be written as

$$\begin{pmatrix} -6 & -2 & 2 \\ -3 & 4 & -3 \\ 2 & 4 & -7 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 15 \\ 13 \\ -9 \end{pmatrix}$$

$$AX = b$$

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where $A = \begin{pmatrix} -6 & -2 & 2 \\ -3 & 4 & -3 \\ 2 & 4 & -7 \end{pmatrix} = [-6,-2,2;-3,4,-3;2,4,-7]$ is the coefficient matrix ,

$X = \begin{pmatrix} x \\ y \\ z \end{pmatrix} = [x,y,z]'$ is the column vector of unknown and $b = \begin{pmatrix} 15 \\ 13 \\ -9 \end{pmatrix} = [15,13,-9]$ is the column vector of known constants. So, we can solve these linear equations in Matlab with the command $X = A \setminus b$ (Note that the $'\setminus'$ symbol is different from the ordinary division $'/'$ sign).we can test the result by performing the command $A * X$ and Matlab answer will be the column vector b as shown in Fig.8 below.

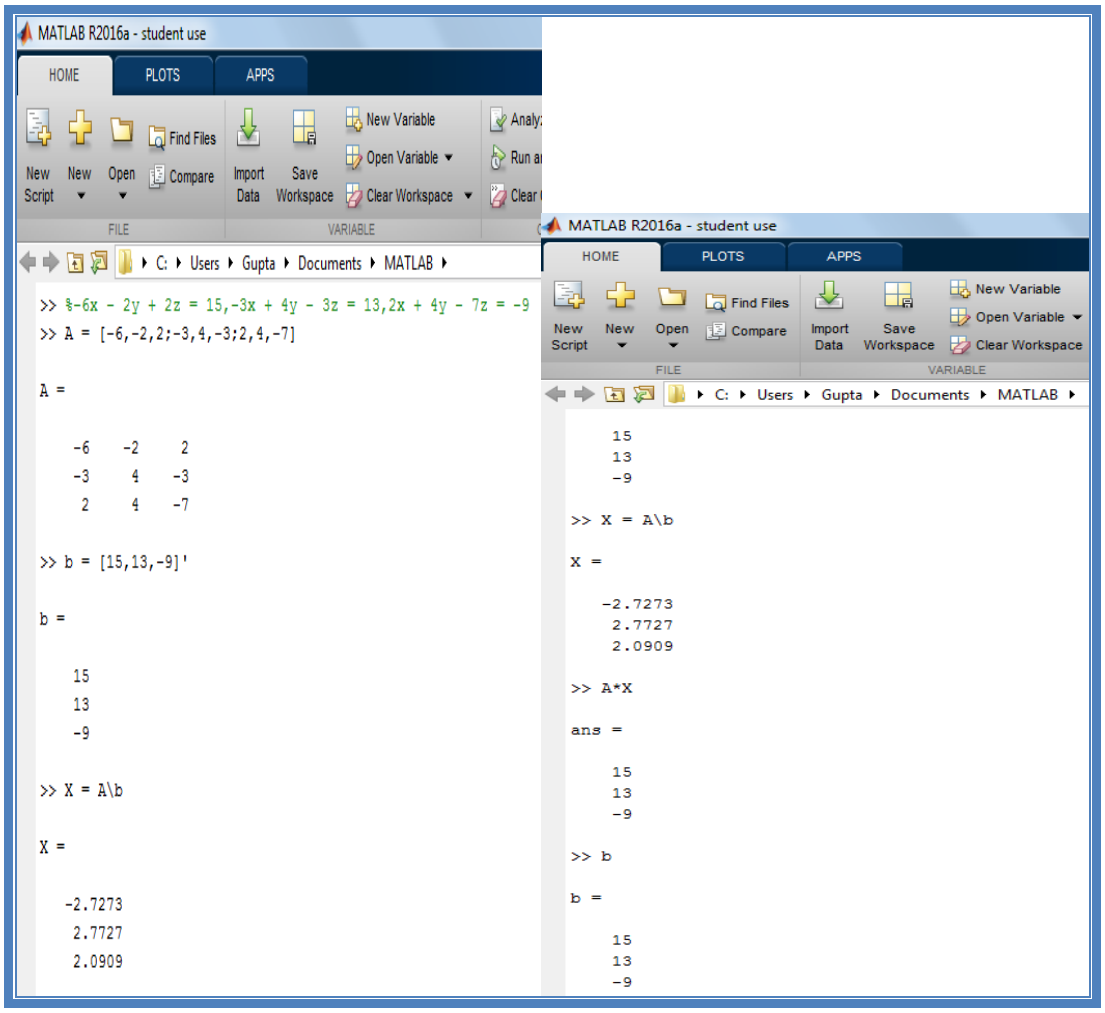

Figure 8 : Solving a system of linear equations

3.6 Operations on Polynomials

In Matlab, a polynomial is represented by an array (row vector) of its coefficients in descending order. For instance, polynomial $p(x) = x^2 - 3x + 5$ is represented by the vector $p = [1,-3,5]$ and the polynomial $q(x) = x^4 + 7x^2 - x$ is represented by the vector $q = [1, 0, 7, -1, 0]$. If any coefficient in the polynomial is missing, then we must enter zeros in the appropriate place(s) in the vector. We can add or subtract two polynomials by just adding or subtracting the coefficient vectors of same size. Matlab can also multiply and

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divide two polynomials by using the command "conv(polynomial 1, polynomial 2) and "deconv(polynomial 1,polynomial 2) respectively. Fig.9 shows various operations on polynomials.

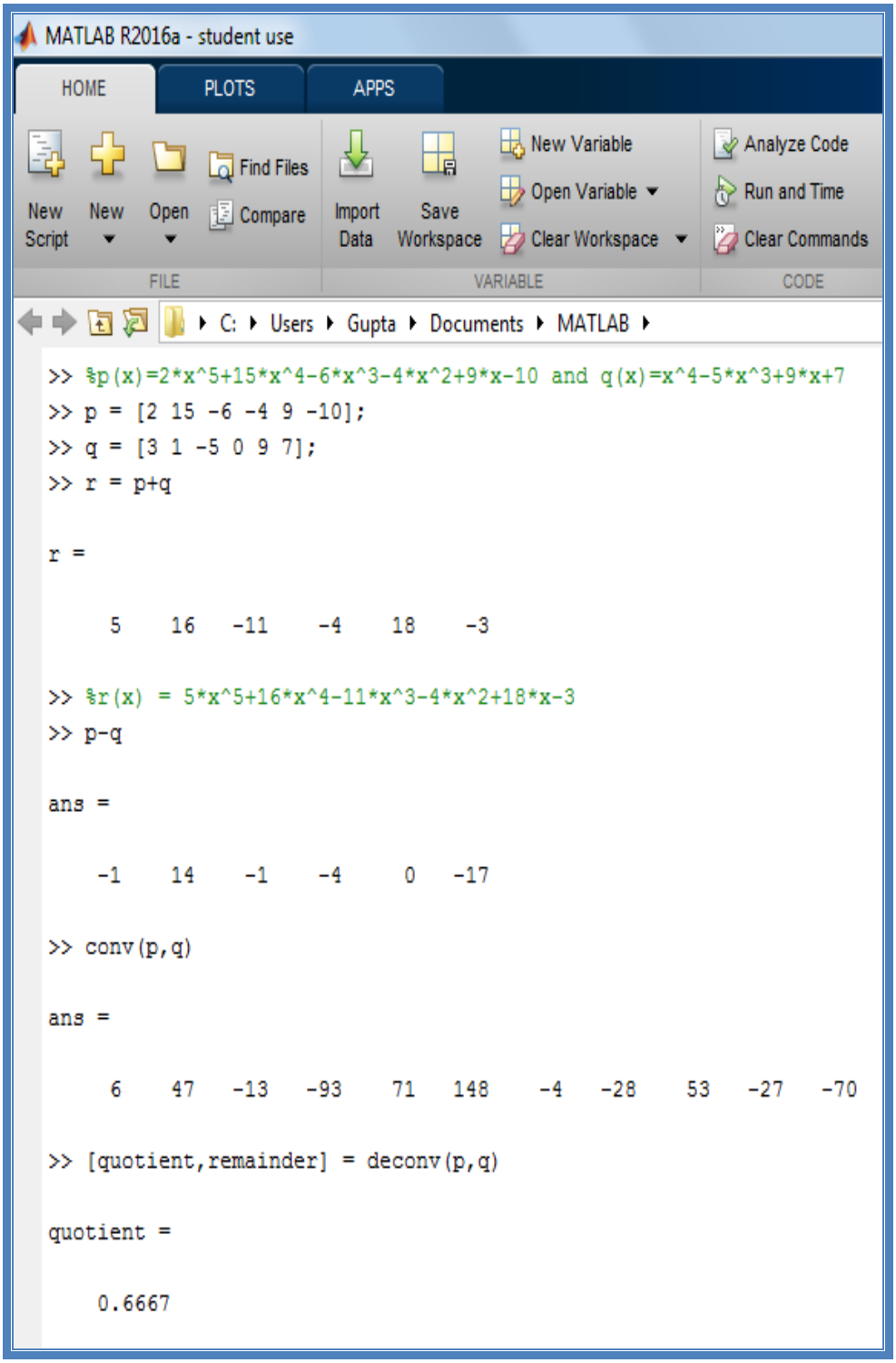

Figure 9 : operations on polynomials

3.7 Solving Polynomial Equations

In Matlab, we can solve quadratic, cubic and higher degree polynomial equations with the command "solve(equation, x)". The function returns the roots of the equation. Fig.10 shows the solution of polynomial equations.

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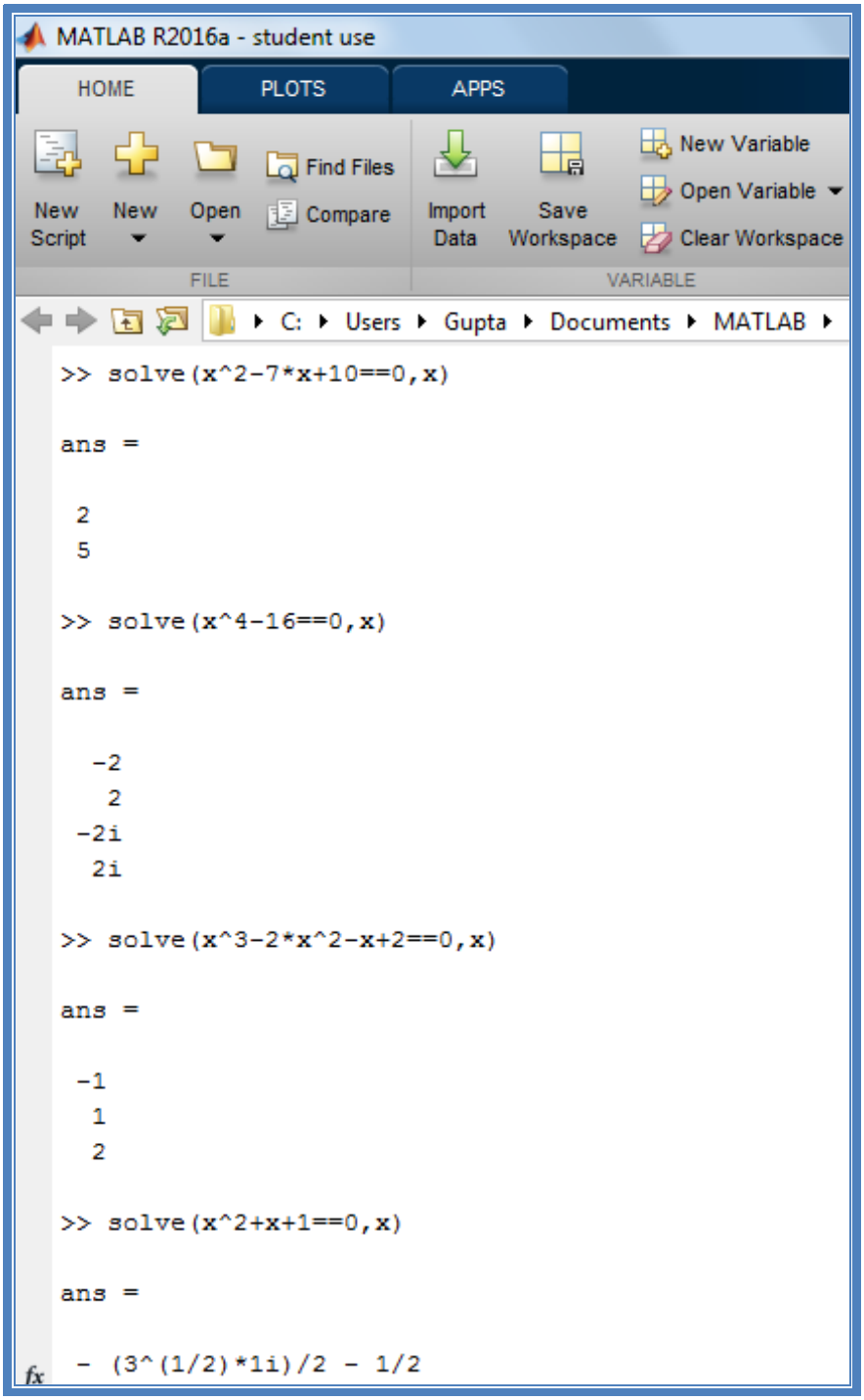

Figure 10 : solution of polynomial equations

3.8 Built-in Matlab functions and plotting

Matlab has the same build - in functions that you see in scientific calculators. A few examples are sin(x), cos(x), tan(x), log(x), sqrt(x), and exp(x). Matlab also recognizes the inverse trigonometric functions. For instance, the inverse tangent is ”atan”. we can use the command “ezplot(‘ function’)” to make 2D(two dimensional) graphs.

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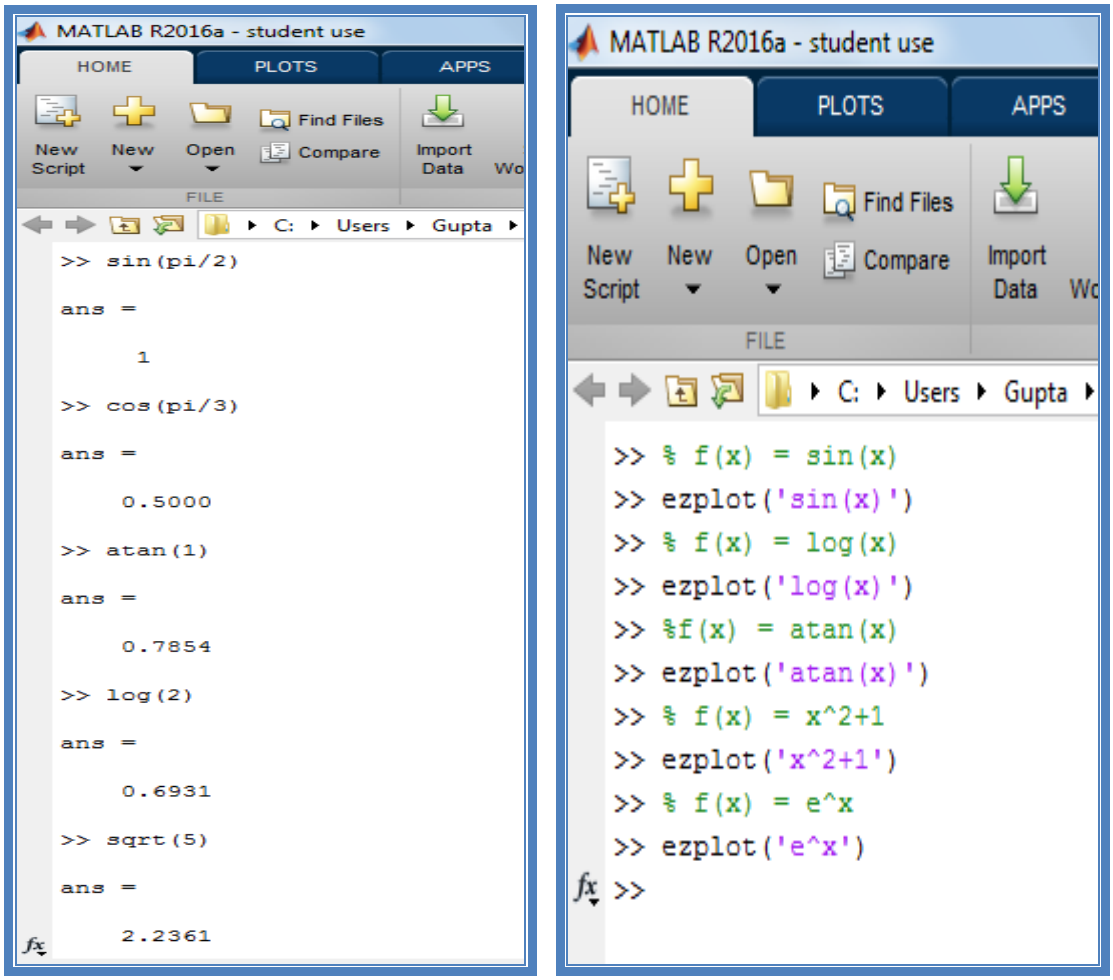

Figure 11 : Matlab build – in functions

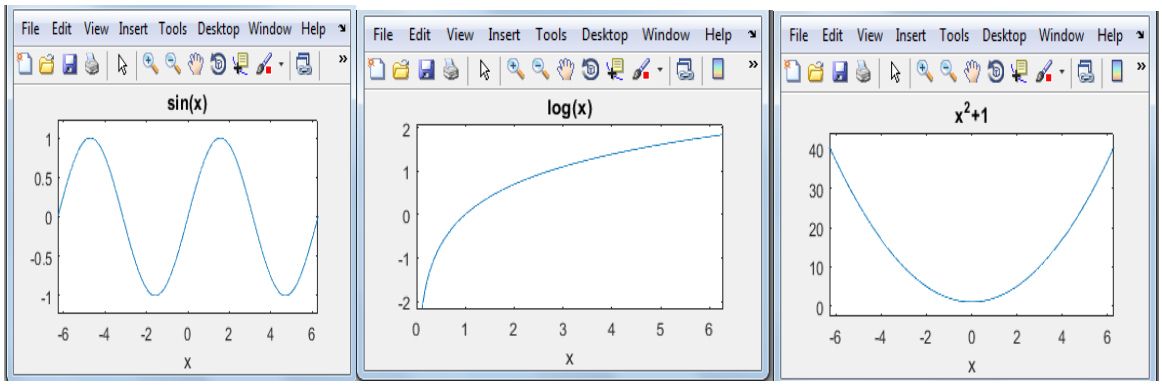

Figure 12 : Plotting functions

IV. CONCLUSION

In this paper, we study how to use computer technology in education. Especially, how to understand basic mathematics using Matlab software through eight selected topics. In our future study, we will judge the performance of the students who study basic mathematics using conservative lecture style and trough Matlab.

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